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Musa voonii, a *New Musa* Species from Northern Borneo and Discussion of the Section *Callimusa* in Borneo

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A new wild banana species, *Musa voonii* Häkkinen, is described and illustrated. The species is abundant in the Lawas area, Sarawak, East Malaysia and in isolated locations within a radius of 200 km from Lawas. Remarks on the sect. *Callimusa* in Borneo are presented.

Key words: Borneo, *Callimusa*, Lawas, *Musa*, *Musa voonii*, wild banana

Borneo is the third largest island in the world. It is divided politically into three parts: The kingdom of Brunei on the north central coast; the Malaysian states of Sarawak and Sabah to the west and east; with Kalimantan of Indonesia making up the larger part to the south. Located on the equator, it has a rainy humid equatorial climate. It has, however, high mountains, which provide many different habitats. During recent ice ages, Borneo was connected to the Asian mainland. To the east of the island is the so-called "Wallace line", which separates the fauna and some of the flora of the Sunda shelf from that of the Sahul shelf (Merrill 1926). Due to the wide variety of plant species that developed earlier as a result of its isolation from the continent, Borneo is considered to be a center of biodiversity in tropical Asia.

Borneo, being part of the primary banana diversity center, has a large number of wild banana species. As banana plants prefer an open exposure, their growth is usually confined to rather small, isolated populations. They consequently manifest much genetic variation. Until the end of the 19th century, the island was covered with dense rain forests (Beccari 1902). Since then, the influence of man such as in agriculture, logging, etc. has led to much clearing of the forest, thereby allowing the wild banana populations to expand their growing area.

History

The Italian botanist Odoardo Beccari was the first to describe wild bananas from Borneo in his classic book "Nelle Forestre di Borneo" (Beccari 1902), republished in Webbia (Martelli 1923). He described and named four: *Musa borneensis* Becc., *M. campestris* Becc., *M. hirta* Becc. and *M. microcarpa* Becc. Beccari made his studies in Sarawak during the period 1865-68.

After Beccari's explorations in Sarawak, studies on wild bananas in Borneo were neglected until Mitsuru Hotta, a Japanese professor, made a series of expeditions in 1963-4, 1968-9 and 1976, mainly in Sabah and Brunei (Hotta 1967, 1987). He described three new species, *Musa flavida* M. Hotta,

M. muluensis M. Hotta and *M. tuberculata* M. Hotta, and gave some critical notes on the other species.

Both botanists studied very small areas and thus could not survey the entire diversity of the genus. More recently, Dr. George Argent from Royal Botanical Garden, Edinburgh described *Musa monticola* [Hotta ex] and *M. suratii* from Sabah (Argent 2000). Then the author described five *M. campestris* Becc. varieties (Häkkinen 2003) and Häkkinen & Meekiong (2004) described a new species, *M. bauensis*.

Botanists have occasionally collected herbarium samples that can be seen in different herbaria but these usually, have been without proper identification.

Characterization

Musa voonii Häkkinen, **sp. nov.**

Planta libere emittens surculos qui arcte aggregant circum parentem. Inflorescentia horizontalis, pedunculo 10 cm longo glabro et viridi. Bracteae imbricatae, extra rubro-purpureae, intra purpureae, apice pallide viridi colore tinctae. Flores masculi 6-8 e quaque bractea, in seriebus duabus dispositi. Ovarium album, ovulis in seriebus 4 in quoque loculo dispositis. Fructuum racemus modice laxus cylindricus, horizontalis vel parum pendulus, fructuum fasciculis 8 et fructibus 6-8 in quoque fasciculo in ordinibus duobus saepe dispositis. Semina depresse obpyriformia tuberculis multis.

Type: MALAYSIA. Sarawak. Trusan road, Lawas. 119 ft. alt., latitude 04°49.375' N., longitude 115°18.867' E., October 23, 2002. *M. Häkkinen, Hadrian Doyok & Puding Padan. Häkkinen SBC 8006* (Holotype SAR, isotype SBC).

Plant suckering freely, clumping close to parent plant, normally 8 - 10 suckers, position vertical. **Leaf** habit semi-erect, mature pseudostem slender up to 3 m but plants present in outlier areas may be only 1.5 m, diameter at base 10 - 12 cm, colour red purple, appearance shiny, sap watery. Petiole light green, with large red to dark brown blotches at the base, petiole canals erect to slightly incurved with narrow green margins curved inwards that become quickly scarious, winged and clasping the pseudostem, leaf blade 180 cm long, 50 cm wide, petiole 80 cm long, colour of upper leaf surface dark green, lower surface green, appearance shiny, without wax on either surface, leaf bases asymmetric and rounded auriculate, with a very corrugated lamina (Fig. 1). **Inflorescence** horizontal, peduncle 10 cm long, glabrous and medium green, sterile bract usually 1, with narrow and short foliage lamina, 50 cm long, base broadened, reddish purple, usually persistent at the opening of the female flowers (Figs. 2A, 3). **Female flowers** 4 - 6 per bract, in two rows, the ovary 6.5 cm long, white, the compound tepal 4.5 cm long, the free tepal obovate, 3.5 cm long, the style 4.0 cm long with a globose ivory stigma 6 mm in diameter and with the ovules arranged in 4 rows per loculus (Figs. 2C, D, 5A-C, H). **Male bud** ovoid-imbricate, 14 cm in length at first, bracts apex intermediate, imbricate, external colour red-purple, internal surface purple, apex tinted with light green, colour fading towards the base, bract scars very prominent on rachis, lifting bract revolute and quickly deciduous, very few wax, moderate grooves on bract (Fig. 2A). **Male flowers** 6-8 per bract in two rows, the compound tepal 4.8 cm long, orange in the upper part and cream green at the base, ribbed at the dorsal angles, with 5-toothed apex, the outer lobes ovate, cuspidate, inner three lobes rotundate, central one larger than the laterals, the free tepal 3.0 cm long, translucent white, oblong, rotundate and simple folding under apex, filaments 1.8 cm long, anthers 2 cm inserted and cream, style white inserted, stigma orange, ovary arched white (Figs. 2E, 5D-F). **Fruit** bunch rather lax, cylindrical, horizontal or slightly pendulous, with 8 hands and 6-8 fruits per hand in two tiers on average, the fingers curved upward, 10 - 11 cm long,

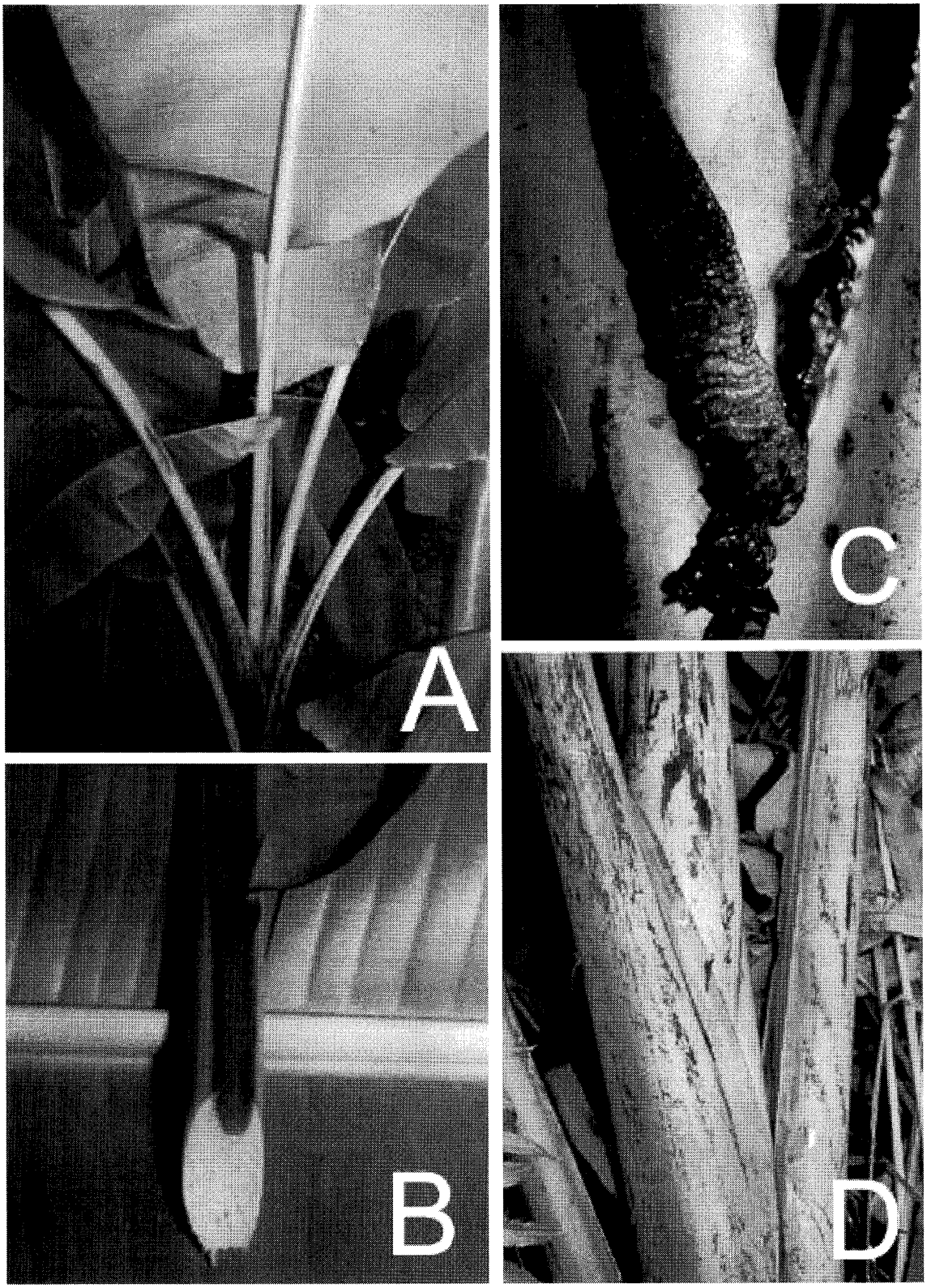

FIG. 1. Leaf characters of *Musa voonii* (A, B and D (*M. Häkkinen et al. SBC 8006*)). A: Semi erects leaf habit and petiole. About 0.1x in size. B: Cross-section of petiole. About 1.3x in size. C: *Musa hirta*. Heavily corrugated petiole margins About 2.5x in size. (Photo at Riv. Rejang, Kapit Div. Sarawak, Malaysia.) D: Petiole margins winged and clasping the pseudostem. About 0.5x in size.

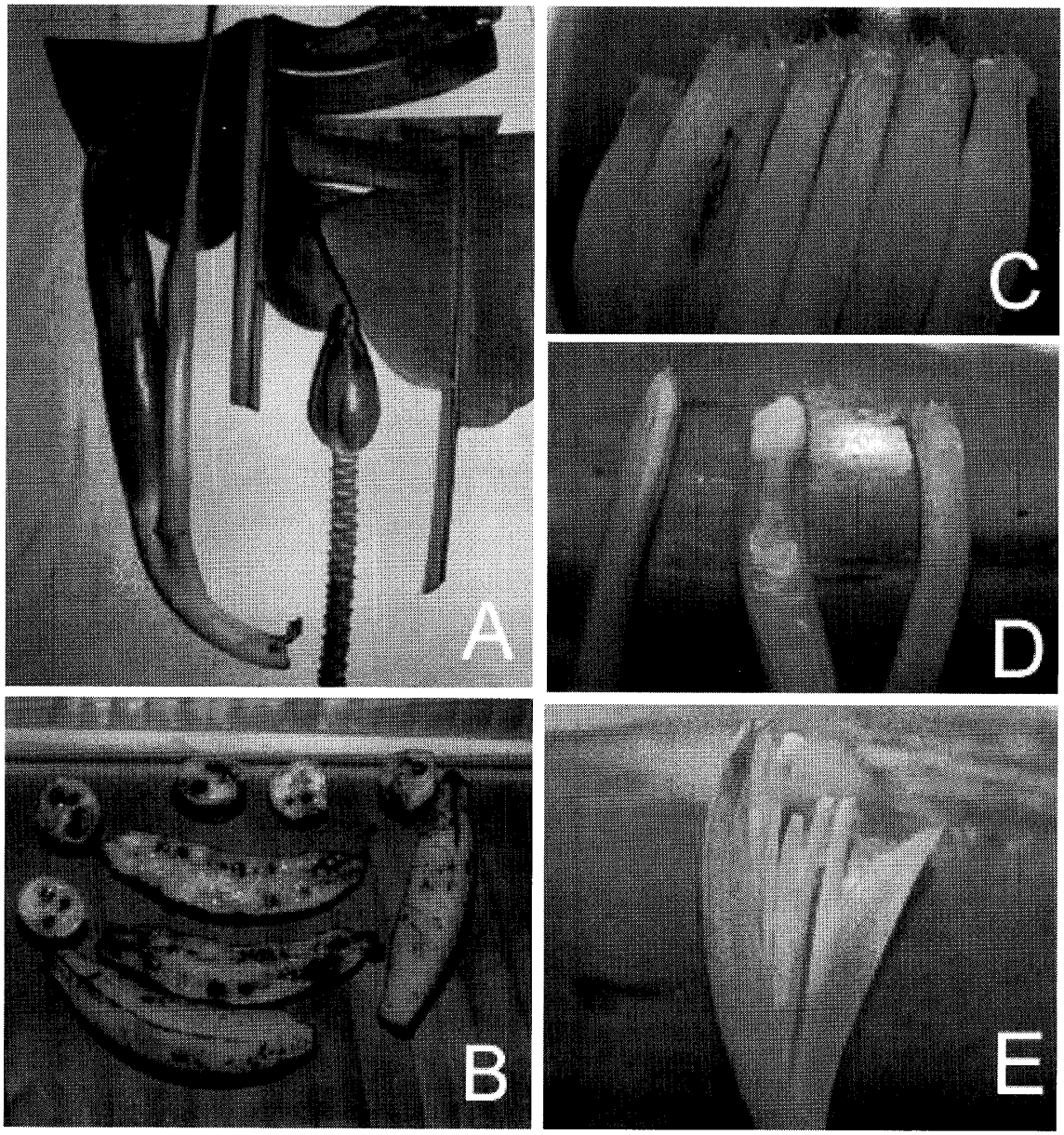

FIG. 2. Inflorescent and flower characters (*M. Häkkinen et al. SBC 8006*). A: Female and male buds. Auriculate leaf base. About 0.3x in size. B: Over ripe fruits showing some seeds. About 1.6x in size. C: Female flowers. About 1.5x in size. D: Female flower parts showing free tepal and stigma. About 1.8x in size. E: Male flower showing from left: compound tepal, stigma, anthers and free tepal. About 2x in size.

about 2 cm in diameter, pronounced ridged, apex long-pointed, pedicel length 10 mm, glabrous, immature fruit peel light-green turning pale yellow with brown spots at maturity, pulp white turning cream when ripe. **Seeds** 60–70 per fruit, depressed obpyriform, 4 mm in diameter, with many tubercles. (Figs. 2B, 4).

Notes: *Musa voonii* is most similar to *M. beccarii* Simmonds, which occurs in Northeast Sabah some 350 kilometres from Lawas, but differs in the following respects: *M. voonii* has horizontal to pendulous inflorescences(Fig. 3), and uniquely arranged ovules in 4 rows per loculus (Fig. 2B, 5H), whereas, *M. beccarii* and other small lowland species of the sect. *Callimusa* have upright inflorescences and seeds in two rows per loculus

FIG. 3. Inflorescence with unripe fruits and male bud. About 0.1x in size (*M. Häkkinen et al. CRP 3*).

(Simmonds & Shepherd 1955, Fig. 5G).

Musa beccarii has a small erect inflorescence with peduncle minutely rough hairy; female flowers 1-3 per bract, which are uniseriate: Male flowers, 2-5 per bract, uniseriate, green in the upper part and yellowish white at the base; fruit bunch small, lax, erect, with 2-5 hands and 1-3 fruits per hand on average. While *Musa voonii* has a horizontal inflorescence with glabrous peduncle; female flowers 4-6 per bract, in two rows; male flowers 6-8 per bract in two rows, orange in the upper part and cream green at the base; fruit bunch rather lax, cylindrical, horizontal or slightly pendulous, with 8 hands and 6-8 fruits per hand in two tiers on average.

The suspicion that *Musa voonii* could be a natural hybrid is unlikely because of its unique characters. Chromosome numbers were not counted.

Musa voonii is named in honour of Senior Research Officer Boon Hoe Voon from Sarawak Agriculture Reseach Centre who has made a lifetime study of the useful plants of Sarawak.

The species was described based on living plants in the field by completing the entire INIBAP *Musa* Descriptor List (IPGRI-INIBAP/CIRAD 1996). Relevant parts of the specimens were deposited as a holotype at the herbarium of the Sarawak Forest Department herbarium (SAR) and isotype at Biodiversity Centre (SBC), Semengoh Sarawak. Suckers and living specimen were delivered for duplication to the Sarawak Agricultural Research Centre, Semengoh. The complete descriptor list is available at University of Helsinki, Finland, as well as at the aforementioned centres.

Habitat: During an exhaustive study of plants of the sect. *Callimusa* in Sarawak, Brunei and Sabah during autumn 2002, the author found populations in the Lawas area, which differed from previously described species. This apparently new species was extremely rare in other locations; however, it was encountered in isolated instances with-

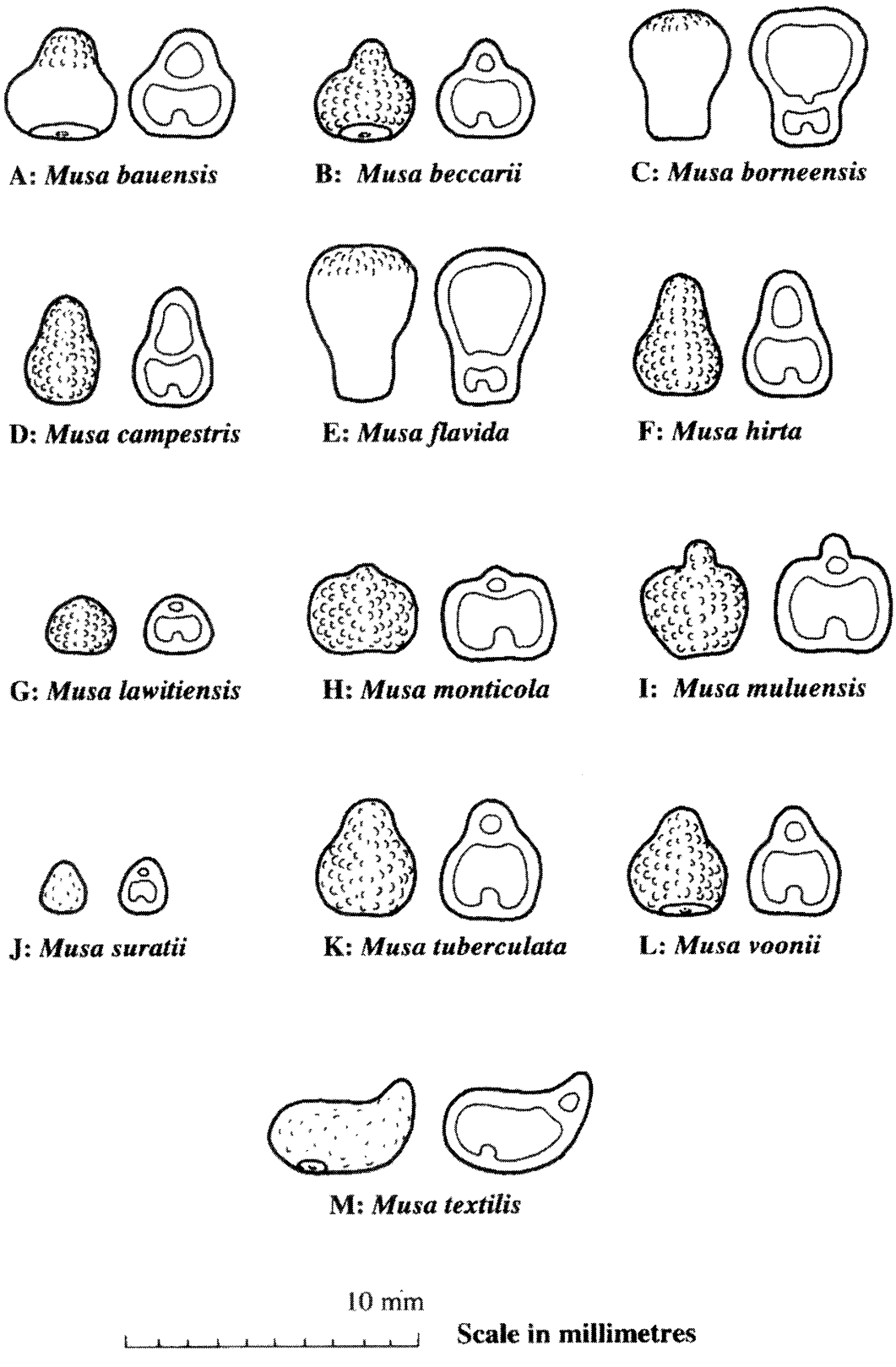

FIG. 4. Drawings of seeds. A-L: *Callimusa* seeds and M: *Australimusa* seeds forms in Borneo. A: *Musa bauensis* (*Häkkinen et al. SBC 8000*). B: *M. beccarii* (*Häkkinen BORH-11-1*). C: *M. borneensis* (*Häkkinen SBC 8012-2*). D: *M. campestris* (*Häkkinen SBC 8012-3*). E: *M. flavida* (*Häkkinen SBC 8012-4*). F: *M. hirta* (*Häkkinen SBC 8012-5*). G: *M. lawitiensis* (*Häkkinen SBC 8012-6*). H: *M. monticola* (*Häkkinen BORH 14-1*). I: *M. muluensis* (*Häkkinen SBC 8012-7*). J: *M. suratii* (*Häkkinen BORH 9*). K: *M. voonii* (*Häkkinen SBC 8006*). L: *M. tuberculata* (*Häkkinen SBC 8012-8*). M: *M. textilis* (*Häkkinen SBC 8012-9*).

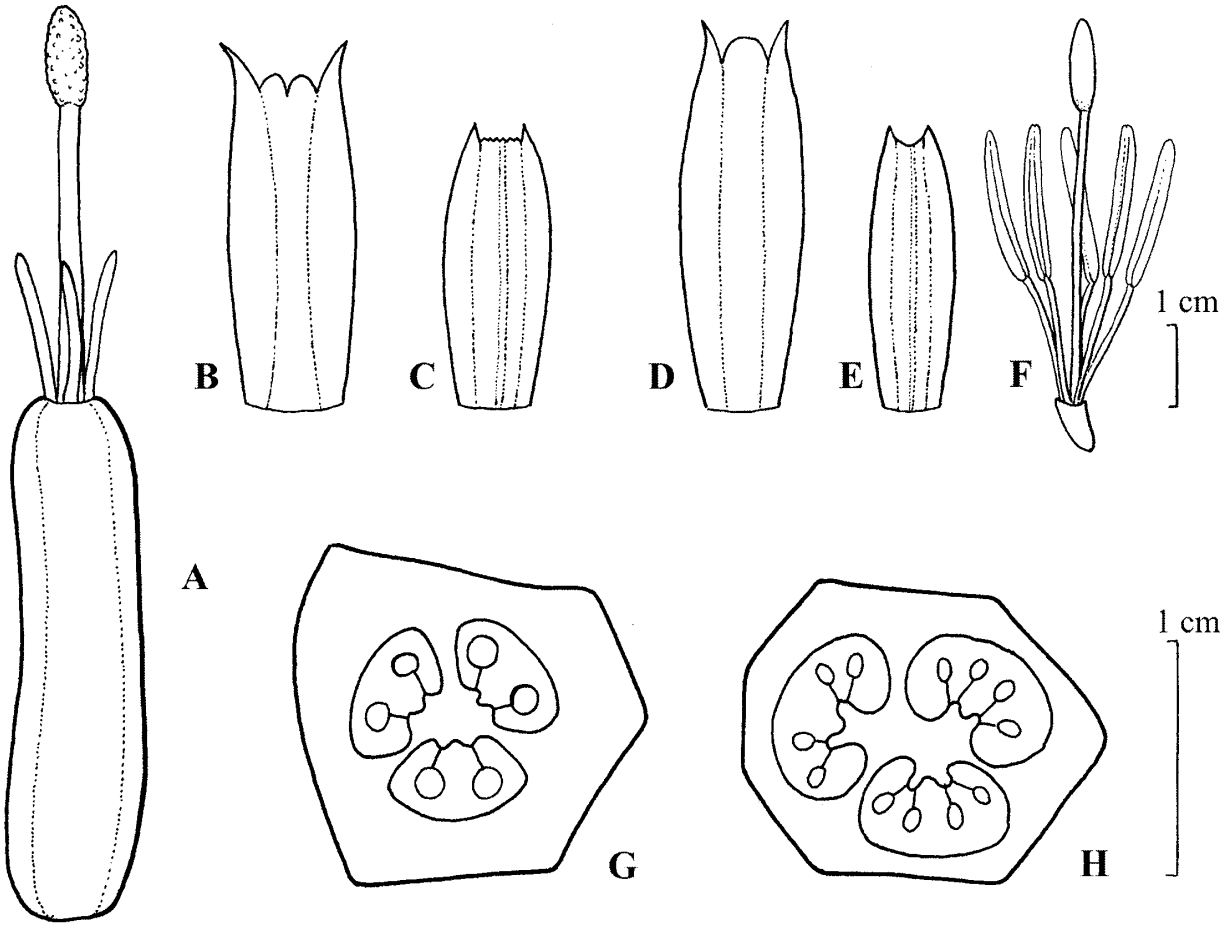

FIG. 5. Drawings of the flower of *Musa voonii* (*M. Häkkinen et al. SBC 8006*). A: Female flower. B: Compound tepal of female flower. C: Free tepal of female flower. D: Compound tepal of male flower. E: Free tepal of male flower. F: male flower. G - H: Arrangement of ovules in wild bananas in Borneo observed from a cross-section of a fruit soon after flowering and before the fruit fills (adapted from Simmonds & Shepherd 1955). G: two-rowed ovules in *M. campestris* Becc. var. *limbangensis* Häkkinen (*M. Häkkinen & J. Jadol SBC 8001* (SAR, SBC)) common in wild bananas. H: four-rowed ovules only observed in *M. voonii* in Borneo.

in 200 km of Lawas in Limbang, Brunei and Sabah. Plants in these isolated areas were similar morphologically to the Lawas population, but were smaller in size, being about 1.5 metres high, compared with the plants in the main population, which are about 3 metres high. Whether this different height is due to environmental or genetic differences was not established. *Musa voonii* is a lowland species. The highest elevation where it was observed was at 200 metres above sea level in the Crocker Range of Sabah. It grows sympatrically with several species such as *M. acuminate* Colla of the sect. *Musa*, *M. campestris* of the sect. *Callimusa*, and feral *M. textilis* Nee of the sect. *Australimusa*. There are three other small species of the sect. *Callimusa* growing in the lowlands: *M. beccarii*, *M. hirta* (Fig. 1C) and *M. campestris*. The regions where these species grow do not overlap. In most instances, there is a 100 km to 200 km belt between the areas where these three species are found that is devoid of other species. There are no obvious topographic boundaries that account for these distinct areas of growth, and the climates in the aforementioned regions are all very similar. The studied areas have a humid equatorial climate and an annual rainfall of 4000 - 7000 mm (Hazebroek & Morshidi 2001). Based on observations, the author believes that seeds of the small *Callimusa* species are distrib-

uted very locally by small mammals such as squirrels and monkeys, which consume them as they feed on the fruit (Häkkinen 2003).

Additional specimens examined: MALAYSIA: Sarawak. Ulu Pandaruan, Rumah Galat, Limbang Division. 145 ft. alt., latitude 4° 30.990 N., longitude 115° 15.667 E., October 4, 2002. *M. Häkkinen & J. Jadol. SBC 8010* (SBC). Sabah. Ulu Kimanis. 90 ft. alt., latitude 05° 45,883 N., longitude 115° 57,930 E., October 17, 2002. *M. Häkkinen, M. Suleiman & J. Gisil. CRP 3* (BORH, H).

Discussion of *Callimusa* in Borneo

The genus *Musa* is one of the three genera (*Musa*, *Musella* and *Ensete*) of the family Musaceae. Various botanists have divided the wild bananas into various sections or subgenera. Sagot (1887) and Baker (1893) distinguished three subgenera for the genus *Musa*, which were: *Physocaulis*, *Eumusa* and *Rhodochlamys*. Cheesman (1947) made the next classification in which the genus was divided into four sections: *Australimusa*, *Callimusa*, *Eumusa* and *Rhodochlamys*. Argent (1976) added one more section *Ingentimusa*, comprised of a single species *M. ingens* Simmonds. Cheesman's classification is based on chromosome numbers and morphological characters (Fig. 4) and it has been widely accepted by botanists.

Recently, however, Wong *et al.* (2001, 2002, 2003) undertook a phenetic examination of the relationships among the four sections (excluding *Ingentimusa*), using the technique of amplified fragment length polymorphism (AFLP). These studies revealed that genetic differences between each section in the same chromosome group may be smaller than some of those within each section. As a result, they proposed to combine sections *Australimusa* and *Callimusa*, into the single section termed *Callimusa* (chromosomes n = x = 10) and the sect. *Musa* and *Rhodochlamys*, into the single section termed *Musa* (n = x = 11). The sect. *Ingentimusa* (n = x = 7) was not examined, thus remaining unchanged. In addition to the AFLP studies, these authors consider that some new species have intermediate seed characters, muting the distinctness of the sections. Also, they cite the papers, in which the distinctness of the sections was questioned (Cheesman 1947, Jarret & Gawel 1995, Shepherd 1999, Simmonds 1962).

However, Wong *et al.* (2003). recognized the convenient utility of Cheesman's four sections and retained them as "informal groups." Thus, four groups were proposed: 1) *acuminata*, 2) *ornata* (the old *Rhodochlamys*) (n = x = 11); and 3) *coccinea* (the old *Callimusa*) and 4) *textilis* (the old *Australimusa*), (n = x = 10). Whether or not these changes will be generally accepted remains to be seen with time and further research. A key need is for more field research on population diversity and to include this diversity in molecular studies, with larger sample sizes. However, the author considers that less confusion would occur if the old names were retained for the "informal groups." Thus, the author proposes that the old sectional names be retained for the groups for easy recognition. Thus "*ornata*" would still be named sect. *Rhodochlamys* and "*coccinea*" would still be named sect. *Callimusa*. The author retains these names in this article.

Observed morphological differences within the sect. Callimusa *in Borneo*

It is considered useful to provide here Cheesman's (1947) original characterization of the sect. *Callimusa*: "Section *Callimusa* (*Musae* bracteis valde imbricatis nitentibus, seminibus turbinatis, dolioliformis vel cylindraceis) has its best known and oldest, representative in *Musa coccinea* Andrews, and is named partly from the fact that that species is the most ornamental in the genus and partly in recognition of the beautifully coloured bracts of other members."

"Seeds are cylindrical, barrel shaped, or top shaped, marked externally by a transverse line or

groove, above which they are warted, tuberculate or variously patterned, below usually smooth, internally with a well developed perisperm chamber above the same line, this chamber empty in the ripe seed".

"Like *Rhodochlamys*, *Callimusa* has no known parthenocarpic member or economic species. It's known members vary widely in size and habit. *Musa borneensis* is similar in appearance and size to a common banana, and has fruits up to 16 cm long in a pendent bunch. *M. coccinea* flowers at a metre high or less, and on account of its small size is popular in conservatories in temperate countries: its inflorescence is erect, very short and compact, and with its narrow bracts and very "open" bud (seven bracts exposing their flowers simultaneously) it is very un-banana-like in appearance. The other species are intermediate between these extremes. They vary much also in number of flowers per bract, both biseriate and uniseriate flowers occurring. Some of the species have a conspicuous corrugated auricle at the base of the petiole, not noted elsewhere in the genus".

The following described species falling within the sect. *Callimusa* have been observed in Borneo field studies by the author: *Musa bauensis*, *M. beccarii*, *M. borneensis*, *M. campestris*, *M. flavida*, *M. hirta*, *M. lawitiensis* Nasution & Supardiyono, *M. monticola*, *M. muluensis*, *M. suratii*, *M. tuberculata* and *M. voonii* sp. nov. In addition, *M. pigmaea* (Hotta 1989) was recently rediscovered but is not described as yet.

The seed morphology of above mentioned species is as follows (Fig. 4): *Musa borneensis* and *M. flavida* have clearly distinct barrel-shaped seeds with a well-developed oil/air chamber without tubercles. The seeds are similar and larger than those of *M. coccinea*, but the embryo is in the opposite end. *Musa campestris* and *M. hirta* have obpyriform seeds with many tubercles. *Musa lawitiensis* and *M. suratii* have seeds similar to those of *M. campesris* and *M. hirta*, but they are much smaller, they are in fact the smallest seeds observed in the genus. *Musa lawitiensis* has many tubercles on the seeds while *M. suratii* has none. *Musa beccarii*, *M. monticola*, *M. muluensis*, *M. tuberculata* and *M. voonii* have depressed obpyriform seeds with many tubercles (Fig. 4). *Musa textilis* in the old section *Australimusa*, which has been introduced into Borneo and become feral, has clearly distinct seeds, long and round with a small oil/air chamber at the opposite end without any tubercles (Cheesman 1949). It is also notable that seeds of all these species are quite distinct from those of the sect. *Musa* such as those of *M. acuminata*.

The corrugated auricle at the base of the petiole, was observed on the following species: *Musa bauensis*, *M. borneensis*, *M. campestris*, *M. flavida*, and *M. hirta*. (Fig. 1C). This is a very clear distinctive character that can be used to separate these five species from others within this section, even when the plants are young and without flowers or fruits. The other six species have a winged petiole base, which clasps the pseudostem.

It has become very clear during this study that *Musa voonii* is absent in most parts of the lowland areas in Northern Borneo, where it is replaced by the small species, *M. beccarii*, *M. hirta*, and *M. campestris* varieties. Biodiversity is very rich in Borneo and new *Musa* species can still be found. With the discovery of *M. voonii*, the number of native *Musa* species in Borneo has increased to 14 excluding *M. textilis*, which is an introduction (Bishop & Curtler 1925, Marsh 1947).

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